

What We Claim Is:

1. A process for thermally crystallizing a polyester polymer comprising:
  - a2) introducing solid amorphous pellets into a liquid medium having a  
5 temperature of at least 140°C within a liquid medium zone within a crystallization vessel and crystallizing said solid amorphous pellets in the liquid medium at a pressure within said zone at or above the vapor pressure of the liquid medium at the liquid medium temperature without increasing the molecular weight of the pellets; and
  - 10 b) while the pressure on at least a portion of the pellets is equal to or greater than the vapor pressure of the liquid medium, separating at least a portion of said pellets and at least a portion of the liquid medium from each other .
2. The process of claim 1, wherein the polyester polymer contains at least 60%  
15 ethylene terephthalate repeat units.
3. The process of claim 1, comprising a1) extruding a molten polyester polymer through a die, underfluid cutting the molten polyester polymer, forming solid polyester pellets, and introducing said pellets into said liquid medium.  
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4. The process of claim 1, comprising a1) feeding a molten polyester polymer through a die to form a molten shaped polymer, and cooling the molten polyester polymer to a surface temperature below 100°C, followed by pelletizing the cooled polyester polymer.  
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5. The process of claim 4, wherein the molten polyester polymer is cooled by spraying water on the polymer in a spray cabinet.
6. The process of claim 1, comprising a1) feeding a molten polyester polymer  
30 through a die and pelletizing the molten polyester polymer before the polyester polymer cools below its  $T_g$  .

7. The process of claim 6, wherein the die has a die head through which the molten polyester polymer is fed, and the molten polyester polymer is cut at the die head.
- 5 8. The process of claim 6, comprising contacting water with the molten polyester polymer at the point where the polymer is pelletized.
9. The process of claim 8, wherein the molten polyester polymer is pelletized underwater in a circulating stream of water at a temperature ranging from 25°C to 100°C.
- 10 10. The process of claim 1, wherein amorphous pellets introduced into the liquid medium have an It.V. ranging from 0.7 to 1.15.
11. The process of claim 10, wherein the solid amorphous pellets are fed to the  
15 crystallization vessel as a slurry in water.
12. The process of claim 10, wherein the degree of crystallinity of the solid amorphous pellets introduced into said liquid medium is 10% or less.
- 20 13. The process of claim 1, wherein the liquid medium comprises water.
14. The process of claim 1, wherein the liquid medium comprises triethylene glycol.
15. The process of claim 1, wherein the liquid medium zone has a liquid medium inlet  
25 and a discharge outlet for the liquid medium and the temperature of the liquid medium at both the inlet and discharge is at least 140°C.
16. The process of claim 1, wherein the liquid medium zone is maintained under a pressure of at least 25 psia.
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17. The process of claim 16, wherein the pressure within the liquid medium zone is at least 100 psia.
18. The process of claim 1, comprising maintaining the pellets in the liquid medium zone for a residence time  $t_{mz}$  of less than 10 minutes.
19. The process of claim 18, wherein the pellets have a degree of crystallization of 25% or more immediately after said separation.
20. The process of claim 19, wherein the degree of crystallization is 30% or more.
21. The process of claim 1, wherein the degree of crystallization immediately after said separation is at least 25% at a residence time  $t_{mz}$  of greater than 0 minutes to 4 minutes or less at a liquid medium temperature ranging from 140°C to 180°C.
22. The process of claim 21, wherein the degree of crystallization is at least 30%.
23. The process of claim 21, wherein the pellet degree of crystallization is 10% or less prior to subjecting the pellet to a liquid medium temperature of at least 140°C.
24. The process of claim 23, wherein the pellet degree of crystallization is about 5% or less prior to subjecting the pellet to a liquid medium temperature of at least 140°C.
25. The process of claim 1, wherein the liquid medium comprises a glycol and crystallization is conducted at a pressure within the liquid medium zone below the vapor pressure of water and above the vapor pressure of the glycol.
26. The process of claim 1, wherein the crystallization is conducted in the liquid medium zone without mechanically induced agitation.
27. The process of claim 1, further comprising:

- 5 c) drying crystallized PET pellets having an It.V. ranging from 0.7 to 1.15 in a drying zone at a zone temperature of more than 140°C; and  
d) introducing the dried pellets into an extrusion zone to form molten PET polymer.
28. The process of claim 27, wherein the process from steps a) and step c) inclusive is conducted in the absence of a solid stating the pellets.
- 10 29. The process of claim 1, wherein the pellets are not solid state polymerized after step b).
30. The process of claim 1, wherein the crystallization vessel is vertically oriented.
- 15 31. The process of claim 1, wherein the flow of the liquid is countercurrent to the flow of the pellets through the liquid medium zone.
32. The process of claim 1, wherein said crystallization vessel comprises a pipe
- 20 devoid of mechanical rotating paddles.
33. The process of claim 32, wherein the flow of the liquid in the pipe is in the same direction as the flow of the pellets.
- 25 34. The process of claim 1, wherein the pellets are dried after separation to remove at least surface moisture on the pellets.
35. The process of claim 1, comprising continuously separating the pellets and the liquid from each other.
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36. The process of claim 35, further comprising simultaneously removing the liquid from the liquid medium zone.
37. The process of claim 11, wherein the pellets comprise a PET polymer, and b)  
5 water and pellets are separated from each other under a pressure of at least 40 psia.
38. The process of claim 1, wherein the pressure on the pellets and liquid immediately prior to or during separation in step b) is at least 70% of the pressure in the liquid medium zone.
- 10 39. The process of claim 1, wherein the volume fraction of the pellets in the liquid medium zone is less than 50%.
40. The process of claim 1, wherein the volume fraction of the pellets separated in  
15 step b) is higher than the volume fraction of the pellets introduced into the liquid medium zone at the top of the crystallization vessel.
41. The process of claim 1, comprising a1) cooling the molten PET polymer to a surface temperature below 100°C followed by pelletizing the polymer underwater and  
20 separating the water from the pellets, and b) separating the liquid medium from the pellets under a pressure of at least 60 psia.
42. The process of claim 1, wherein the polyester polymer comprises a PET polymer.
- 25 43. The process of claim 42, wherein the polyester polymer consists of a PET polymer.
44. The process of claim 1, comprising a2) crystallizing the amorphous pellets under water for less than 10 minutes residence time  $t_{mz}$  within the liquid medium zone, and b)  
30 separating water from the pellets at a pressure of at least 50 psia,

- 45      The process of claim 1, wherein the pellets are crystallized in the liquid medium in the absence of a surface active agent added to the liquid medium to prevent agglomeration of the pellets.
- 5      46.      The process of claim 1, comprising maintaining the pellets in the liquid medium zone for a residence time  $t_{mz}$  of less than about 7 minutes.
47.      A process for making a molded part or sheet from pellets comprising:
- 10          c)      drying non-solid stated pellets comprising virgin polyester pellets having an  $I_t.V.$  ranging from 0.7 to 1.15 in a drying zone at a zone temperature of at least 140°C;
- d)      introducing the dried pellets into an extrusion zone to form molten PET polymer; and
- 15          e)      forming a molded part or sheet from extruded molten PET polymer.
48.      The process of claim 47, wherein the residence time of the pellets in the drying zone ranges from 0.50 hours to 16 hours.
- 20      49.      The process of claim 48, wherein the temperature in the drying zone ranges from 140°C to 180°C.
50.      The process of claim 47, wherein the PET pellets have an average degree of crystallization ranging from 25% to 40%.
- 25      51.      The process of claim 47, comprising introducing into the dryer zone PET pellets obtained by crystallizing solid amorphous pellets submerged in a liquid medium in a liquid medium zone within a crystallization vessel at a liquid medium temperature within said zone ranging from greater than 140°C to 200°C and a pressure within the liquid
- 30      medium zone at or above the vapor pressure of the liquid medium to form crystallized pellets which have not undergone a substantial increase in molecular weight during

crystallization followed by separating the liquid medium and the pellets from each other under a pressure equal to or greater than the vapor pressure of the liquid medium.

52. The process of claim 47, conducting said crystallization in the liquid medium  
5 zone without rotating mechanically induced agitation.

53. The process of claim 47, wherein the pellets have been crystallized at a temperature greater than or equal to 40°C below the drying temperature.

10 54. The process of claim 47, comprising forming a bottle preform.

55. The process of claim 47, comprising forming a thermoformable sheet.

56. A process for thermally crystallizing a polyester polymer comprising:  
15 a1) forming solid amorphous pellets comprising underfluid pelletizing with a pelletizer, and  
a2) introducing the solid amorphous pellets into a liquid medium having a temperature of at least 140°C within a liquid medium zone within a crystallization vessel and crystallizing said solid amorphous pellets in the liquid medium at a  
20 pressure within said zone at or above the vapor pressure of the liquid medium at the liquid medium temperature without increasing the molecular weight of the pellets.

57. The process of claim 56, comprising a1) directing a polyester polymer at above its  
25  $T_g$  through a die, cutting the polyester polymer, and between the time the polyester polymer is directed through the die and before the polymer is introduced into the liquid medium, cooling at least the surface of the polyester polymer to below the  $T_g$ , thereby converting the polyester polymer to a solid pellet, followed by introducing the solid pellet into the liquid medium.

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58. The process of claim 56, wherein the crystallization vessel comprises a housing containing the liquid medium and the pelletizer.

59. The process of claim 58, wherein the polyester polymer is cut underfluid resulting  
5 the immediate contact of the solid amorphous pellets with the liquid medium upon formation of the pellets.

60. The process of claim 58, wherein the polyester polymer is cut underfluid, and a stream of cool liquid at a temperature below 140°C is introduced into the housing against  
10 a die plate face through which molten polyester is directed into the housing and/or against the cutting blades of the pelletizer.

61. The process of claim 56, wherein the liquid used for the underfluid pelletizing is the liquid medium.  
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62. The process of claim 56, wherein the liquid medium circulates within the liquid medium zone with a current directing the solid amorphous pellets away from the pelletizer and directly or indirectly into a pipe within which the pellets are crystallized.

20 63. The process of claim 62, wherein the pipes are devoid of internal mechanically rotating blades, in-line mixers, weirs, and baffles.

64. The process of claim 62, wherein the pipes have a continuous flow of liquid medium in the same direction as the flow of the pellets.  
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65. A process for thermally crystallizing solid pellets in a pipe comprising directing a flow of solid pellets in a liquid medium through a pipe having an aspect ratio L/D of at least 15:1, wherein the solid pellets are crystallized in the pipe at a liquid medium temperature greater than the  $T_g$  of the polyester polymer.  
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66. The process of claim 65, wherein the pellets are crystallized in said pipe at a liquid medium temperature exceeding the boiling point of the liquid medium at 1 atmosphere.
- 5 67. The process of claim 65, wherein the pellets are crystallized in said pipe at a liquid medium temperature of at least 140°C.
68. The process of claim 65, wherein the pellets and liquid medium in said pipe are under a pressure equal to or greater than the vapor pressure of the liquid medium.
- 10 69. The process of claim 65, further comprising introducing polyester pellets having a degree of crystallinity of no more than 15% into said pipe.
- 15 70. The process of claim 69, comprising introducing solid pellets having a degree of crystallinity of no more than 10% into said pipe.
71. The process of claim 65, wherein the pipe has an aspect ratio L/D of at least 25:1, the pellets are crystallized in said pipe at a liquid medium temperature of at least 140°C, the pellets and liquid medium in said pipe are under a pressure equal to or greater than the vapor pressure of the liquid medium, and the pellets .
- 20 72. The process of claim 71, comprising introducing solid pellets having a degree of crystallinity of no more than 15% into said pipe.
- 25 73. The process of claim 72, comprising crystallizing said solid pellets in said pipe to a degree of crystallinity of at least 30%.
- 30 74. The process of claim 65, comprising introducing solid polyester pellets having a degree of crystallinity of 15% or less into said pipe and crystallizing said pellets to a degree of crystallinity of at least 30% in said pipe in 10 minutes or less.

75. The process of claim 74, comprising conducting said crystallization in 4 minutes or less.

76. The process of claim 65, wherein the pipe is devoid of mechanically rotating  
5 paddles, in-line mixers, weirs, or baffles.

77. The process of claim 65, wherein the flow of the liquid medium is in the same direction as the flow of the pellets.